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On Farm Energy Analysis of Sweet Orange Production in Nigeria

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Introduction

Efficient use of energy is one of the principal requirements of sustainable agriculture. Energy use in agriculture has been increasing in response to increasing population, limited supply of arable land, and a desire for higher standards of living. Continuous increasing demands of food products have resulted in intensive use of chemical fertilizers, pesticides, agricultural machinery, and other natural resources. Agriculture uses energy directly as fuel or electricity to operate machinery and equipment, to heat or cool buildings, and for lighting on the farm, and indirectly in the fertilizers and chemicals produced off the farm. Energy's share of agricultural production expenses varies widely by activity, production practice, and locality. Energy input–output analysis is usually used to evaluate the efficiency and environmental impacts of production systems. The aims of this study were to determine the total amount of input–output energy used in sweet orange production in a group of citrus research farms in Nigeria, to investigate the distribution of different energies utilized during management practices and to evaluate the efficiency of input energy consumption and thereafter, making an economical analysis of citrus production.

Material and Methods

Research farms used for investigation

The study was carried out in a group of citrus research farms being managed by the National Horticultural research Institute of Nigeria based in Ibadan in the south western part of Nigeria. The institute was set up by the federal government of Nigeria to conduct research into the genetic improvement, production, processing, storage, utilization and marketing of tropical fruits, vegetable and ornamental plants.

Energy analysis procedures

Firstly, the amounts of inputs used in the production of citrus were specified in order to calculate the energy equivalences in the study. Energy input includes human labor, machinery, diesel fuel, chemical fertilizer, pesticides and seed amounts and output yield include grain of citrus. Human energy expenditure was quantified by multiplying the number of persons engaged in an operation by the man-hour requirement and energy equivalent for human power. According to Jekayinfa and Bamgboye (2004, 2006[a], 2006[b]); Jekayinfa (2007); Jekayinfa and Olajide (2007) at the maximum continuous energy consumption rate of 0.30 kw and conversion efficiency of 25 percent, the physical power output of a normal human labour in tropical climates is approximately 0.075 kw sustained for an 8-10 h workday.

Basic information on energy inputs and citrus yields were entered into SPSS 15 spreadsheets. Based on the energy equivalents of the inputs and output output–input energy ratio, energy productivity, specific and energy net energy gain were calculated as used by previous researchers (Singh et al., 2002). The input energy is also classified into direct and indirect and renewable and nonrenewable forms Energy equivalents for different inputs and outputs in agricultural production were used. The following energy use indices were estimated from the collected input and output data:

$$Output - input\ ratio = \text{(Output energy (MJ/ha))/(Input energy (MJ/ha))} \quad 1$$

$$Energy\ productivity = \text{(Citrus output (kg/ha))/(Input energy (MJ/ha))} \quad 2$$

$$Net\ energy\ gain = Energy\ output\ \text{(MJ/ha)-}\ Energy\ input\ \text{(MJ/ha)} \quad 3$$

$$Specific\ energy = \frac{Input\ energy\ \left(\frac{MJ}{ha}\right)}{Citrus\ Output\ \left(\frac{kg}{ha}\right)} \quad 4$$

Indirect energy consists of seeds, fertilizers, pesticides and machinery energy while direct energy covered human labor and diesel fuel used in the citrus production. Nonrenewable energy includes diesel, pesticide, fertilizers and machinery, and renewable energy consists of human labor and seeds. In the last part of the research, economic analysis of citrus production was investigated. Net income and benefit–cost ratio as economic indicators was calculated based on the existing price of the inputs and outputs. The net income was calculated by subtracting the total cost of production from the gross income of production per hectare. The benefit–cost ratio was calculated by dividing the net income of production by the total cost of production per hectare.

Results and Discussion

Energetics of producing citrus fruits (sweet orange)

The energy input and output, yield, energy use efficiency, specific energy, energy productivity and net energy in the citrus plantation used for this study are shown in Table 1. From Table 2, Energy use efficiency (energy ratio) was calculated as 1.67. In this study, the average energy productivity of sweet orange production was 0.88. This implies that 0.88 orange output was obtained per unit energy.

The distribution of total energy input as direct, indirect, renewable and non-renewable forms. The total energy input could be classified as direct energy (86.72%), indirect energy (12.88%) and renewable energy (37.20%) and non- renewable energy (46.52%) as shown in Table 3. The implication of these results is that the energy use pattern in the investigated citrus research farms is based more on non-renewable and direct energy sources than on the renewable and indirect sources, which in other words, shows the more dependence on fossil-based energy sources like diesel and electricity. It therefore follows that citrus production in Nigeria is very sensitive to possible changes in the price of fossil fuels and their supply availability.

Table 1 Energy consumption and energy input–output relationship for citrus (sweet orange) production in Nigeria

Input Quantity per unit area (ha)	Energy equivalent (MJ/unit)	Total energy equivalent (MJ)	Percentage of total energy input (%)
Human labour		**16150.40**	**34.63**
Land preparation	1.96	98.00	0.21
Cultural practices	1.96	14817.60	31.77
Harvesting	1.96	1234.80	2.65
Machinery		**732.97**	**1.57**
Land preparation	62.70	198.76	0.43
Cultural practices	62.70	284.66	0.61
Transportation	62.70	249.55	0.54

Chemical fertilizer		**3636.00**	**7.80**
Nitrogen	60.60	3636.00	7.80
Phosphorus	11.10	0	0
Potassium	6.70	0	0
Farm yard manure	0.3	**1200**	**2.60**
Chemicals		**436.50**	**0.90**
Pesticides (general)	199	298.50	0.60
Fungicides	92	138.00	0.30
Herbicides	238	0	0
Diesel-oil	56.31	**16893.00**	**36.22**
Electricity	11.93	**7401.97**	**15.87**
Water for irrigation	0.63	**189.32**	**0.41**
Total energy input		**46640.16**	**100**
Yield	1.9	**77900.00**	
Energy output–input ratio		**1.67**	

Economic analysis of citrus fruits (sweet orange)

The total expenditure for the production was 5590 \$ ha^{-1} while the total gross production value was found to be 12300 \$ ha^{-1}as shown in Table 4. The benefit–cost ratio from sweet orange production in the surveyed research farms was calculated to be 2.2. The net return from sweet orange production obtained was 6710\$ ha^{-1}. Energy management is an important issue in terms of efficient, sustainable and economic use of energy. Energy use in citrus production is not efficient and detrimental to the environment due to mainly excess input use. Therefore, reducing these inputs would provide more efficient fertilizer application and diesel. Furthermore, integrated pest control techniques should be put in practice to improve pesticide use. It can be expected that all these measurements would be useful not only for reducing negative effects to environment, human health, maintaining sustainability and decreasing production costs, but also for providing higher energy use efficiency.

Table 2: Energy input–output ratio in citrus (sweet orange) production

Items	**Unit**	**Value**
Energy input	MJ ha^{-1}	46640.16
Energy output	MJ ha^{-1}	77900.00
Citrus yield	kg ha^{-1}	41000
Energy use efficiency	-	1.67
Specific energy	MJ kg-^{1}	1.14
Energy productivity	kg MJ^{-1}	0.88
Net energy	MJ ha^{-1}	31259.84

Table 3. Total energy input in the form of direct, indirect, renewable and nonrenewable for citrus (sweet orange) production (MJ ha^{-1}).

Form of energy	**Value (MJ ha^{-1})**	**% of total energy input**
Direct energy[a]	40445.37	86.72
Indirect energy[b]	6005.47	12.88
Renewable energy[c]	17350.4	37.20
Non-renewable energy[d]	21698.47	46.52
Total energy input	46640.16	

[a]Includes human labor, diesel, electricity
[b]Includes seeds, fertilizers, manure, chemicals, machinery.
[c]Includes human labor, seeds, manure.
[d]Includes diesel, chemical, fertilizers, machinery.

Table 4 Economic analysis of citrus (sweet orange) production in Nigeria

Cost and return components	Value
Product yield (kg ha^{-1})	41000
Sale price of product ($ kg^{-1})	0.30
Total gross value of production ($ ha^{-1})	12300
Total cost of production ($ ha^{-1})	5590
Net return ($ ha^{-1})	6710
Benefit Cost ratio	2.2

Conclusions and Outlook

In this study, energy consumption for input and output energies in sweet orange production was investigated in a group of citrus research farms in Nigeria. Data for analyses were collected on the farm as the operations were taking place on yearly basis. Average total energy consumption in sweet orange production was 46.64 $GJha^{-1}$. About 35% was generated by human labour, 38% from diesel oil and machinery, while other contributed 29% of the total energy input. The total energy input could be classified as direct energy (86.72%), indirect energy (12.88%) and renewable energy (37.20%) and non- renewable energy (46.52%). Results of the study generally indicated a fair energy use pattern which could still be improved with reduction in energy inputs from cultural practices and a methodological shift from the use of energy from non-renewable sources to renewable ones.

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